Closing the Loop of Patient Care—A Clinical Trial of a Computerized Discharge Medication Program

Daniel Z. Sands, MD, MPH, Charles Safran, MD, MS

Center for Clinical Computing, Harvard Medical School and Beth Israel Hospital, Boston, MA

A frustrating time for hospitalized patients and their primary care providers is after discharge from the hospital, because of changes in patients' medications. We developed a computer program to improve the discharge process, by providing guidance to the physician writing the prescriptions, offering educational material to the patients, and providing electronic notification of medication changes to the primary care providers. During a one-year clinical evaluation of this system, in which use of the program was voluntary, 1000 patients were discharged through the program. House officers tended to use the program more often for patients who were older and in the hospital longer. Both house officers and primary care physicians found the program extremely useful, and the process took no longer than the manual method of creating discharge medication lists. Patients who were discharged using this program may have had better adherence to medication regimens. We conclude that computer-assisted compilation of a discharge medication list is a useful method for improving the discharge process.

In the 1990's, patients are hospitalized for ever-shortening lengths of time, and experience a greater intensity of activity in these hospitalizations than ever before. This trend is likely to continue, as health care reform and capitated payment further discourage the use of costly inpatient facilities. As a result, patients spend more time outside the hospital and primary care assumes increasing importance. This means that primary care physicians are busier than ever and are caring for increasingly ill patients outside the hospital, so that continuity of care from the inpatient to the outpatient setting becomes essential. At the same time, patients are expected to understand complicated lists of medications and instructions.

The effects are that ill patients are being sent home from the hospital not fully understanding changes in their medications, physicians and nurses cannot adequately educate patients about their medications, house officers are having difficulty developing an inclusive list of medications at the time of discharge, and primary care providers are spending large proportions of encounters trying to determine which medications their patients are supposed to be taking. Inadequate patient education about their medications leads to nonadherence to regimens[1] and contributes to adverse drug reactions[2]. Nonadherence is estimated to cost the United States $100 billion per year in health care costs and lost productivity[3].

We developed a computer program to respond to these problems, and investigated its efficacy through a clinical trial.

METHODS

Setting

The study was performed on the general medical service of Boston's Beth Israel Hospital, a 500-bed major teaching hospital of Harvard Medical School. For almost 20 years the hospital has had a heavily used integrated clinical information system, the CCC system [4]. For five years the general medical practice has used a part of the CCC system, the online medical record (OMR)[5], through which all aspects of outpatient primary care have been managed, including problems, medications, and notes. In addition to providing patient information, the system is heavily used for clinical decision support.

Problem Assessment

Patients' satisfaction with their education about medications at the time of discharge was assessed through a multi-hospital survey[6]. Interns, nurses, and primary care physicians were interviewed both singly and in small groups. Flow charts were constructed to outline the cur-

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rent process of sending a patient home from the hospital, focusing on medication-related issues. Problem areas were identified and solutions proposed.

System Development

A new process was outlined on a flow chart. The new process was able to take advantage of the information resources available on the CCC system, and implement our practice decision that the OMR medication list should be the current record of our patients' medications. The new system would be triggered by the house officer who had been caring for the patient in the hospital, and its use would be voluntary.

The system works as follows. Each medication that is ordered for the patient at the time of discharge is shown to the house officer for approval, discontinuation, or modification. To help with the decision making, the house officer can view the patient's OMR medication list or the online PDR while reviewing medications. Once the house officer has decided whether to approve, discontinue, or change the dosage of each of these inpatient drugs, the program checks the OMR medication list for drugs that may have been omitted and prompts the house officer to reevaluate these medications as well.

When the list is finalized, the program displays a list of all the medications the house officer is about to prescribe, sorted by therapeutic class. It also displays potential drug-drug interactions. On the basis of this information, the list can be edited.

Once approved, this list of medications is stored in the OMR as the patient's current medication list, which is then instantly available to outpatient providers who may be caring for the patient. The program then informs the house officer of any special blood tests that need to be ordered, according to the patient's specific medications.

The final discharge prescriptions and patient education monographs[7] are then printed on a laser printer, along with medication lists for both the paper chart and the patient. Finally, an electronic message is sent to the patient's primary care provider indicating which changes were made in the patient's medications.

Study Design

The study subjects were patients hospitalized for more than two days who were discharged from the medical service to their homes between Jan. 10, 1993, and Jan. 10, 1994. Eligible patients were those for whom more than two scheduled medications were ordered at the time of discharge. For patients hospitalized more than once, only the first eligible discharge was analyzed.

Nursing and secretarial staff on two floors in the hospital were taught to use new printers required for the intervention, and two other floors served as controls.

The discharge medication menu option was available to all house officers, but the actual discharge medication program was executed only if the patient being discharged was on an intervention floor. If the patient was located on a control floor, the program asked questions of the user about the number of prescriptions written and the time it took, but we did not allow online ordering of medications.

All medical interns were reminded about the program's existence by electronic mail monthly during the first three months of the study, and they were reminded again during house officer meetings early in the study and in the 11th month.

Data Collection

Details about program use were stored automatically. Comments from users were also collected. At the end of the study, the house officers, primary care physicians, and nurses were sent electronic questionnaires[8] inquiring about their use and satisfaction with the program.

Patient outcomes included the number of days until emergency readmission to the hospital, the patient's length of stay, and the number of medications the patient was given at the time of discharge. For patients who were readmitted within 30 days, readmissions attributable to medication errors were determined by the hospital's utilization review department (blinded to the study group of the patient).

Members of a random sample of English-speaking patients who were discharged during the first four months of the study from an intervention floor and from a control floor were con-

tacted by telephone and asked about their satisfaction with their hospitalization, medication teaching in the hospital, and their adherence to discharge medication regimens. The questionnaire used the inquiries in an ongoing study[6], augmented with questions adapted from the Medical Outcomes Study[9].

Other data collected were patient demographic and insurance information, the number of procedures performed during the hospitalization, the number of inpatient medications at the time of discharge, whether the patient was followed in our hospital-based group practice, where the OMR is used for outpatient care, and whether the patient had an illness related to HIV infection (major diagnostic class of 25).

Statistical Analysis

Analysis was performed on an intention-to-treat basis. Fisher's exact test and two-tailed t-tests were performed on categorical and continuous variables, respectively. The same tests were also used to determine and adjust for the composition of each floor. Chi squared tests for trend were applied to program usage data. Secondary analyses were performed to identify the patients for whom the intervention was actually applied, and the effect of it. All analyses were performed using SAS[10].

RESULTS

Baseline Data

Three thousand nine hundred and sixty-four patients were discharged from the intervention floors and 2237 from the control floors during the study period. Two thousand one hundred and sixty-five patients met the entry criteria for inclusion in the analysis, 63 percent of whom were from the intervention floors. There were no differences between the intervention and control groups with respect to sex, ethnic group, age, proportion receiving outpatient care at Beth Israel, insurance status, HIV status, length of hospitalization, number of procedures, or number of inpatient medications.

User Data

Eighty-three percent of primary care providers responded to the survey with a median response time of 1 day. Almost 90 percent said that notification of medications at the time of discharge saved them time, and more than 90 percent felt that electronic notification was the most useful.

Seventy-one percent of house officers responded to the survey with a median response time of 2 days. Sixty-one percent of those said they had used the program, and 68 percent of the users felt it made deciding about medications easier. Seventy-seven percent felt that the program took no more time than the manual process, and 41 percent felt that it saved them time. More than half felt that their clerical work was easier, and more than 82 percent felt the program was usually helpful. All thought that it was worth the time and effort needed to use it.

Of the house officers who had not used it, 93 percent felt such an approach would be useful. Reasons for not using the program included not knowing it existed and not knowing how to use it.

Seventy-two percent of nurses responded to the survey with a median response time of nine days. Half had remembered receiving printouts from the program, 82 percent felt that it made their clerical work easier, and 30 percent were more comfortable teaching patients with this information. About half felt that the patient attained more knowledge because of this information.

Patient Data

There was no difference in length of stay, time to emergency readmission, or number of medications prescribed between the two groups. The amount of time spent doing the discharge medications was significantly lower in the intervention group (12 vs. 6 minutes, p=0.048); this was offset by slightly more medications (7.4 vs 6.3, p=0.052), so the number of minutes per medication was unchanged (1.3). One adverse drug event was determined to be contributing to early unplanned readmission, and this occurred in a patient from the control group.

The program was used for 38 percent of eligible patients during the study period. The proportion ranged from 42 to 69 percent during the first five months of the study (χ^2 for trend=0.02, p=0.88), and from 19 to 33 percent after the arrival of the new interns (χ^2 for trend=5.4, p=0.02; see Figure 1).

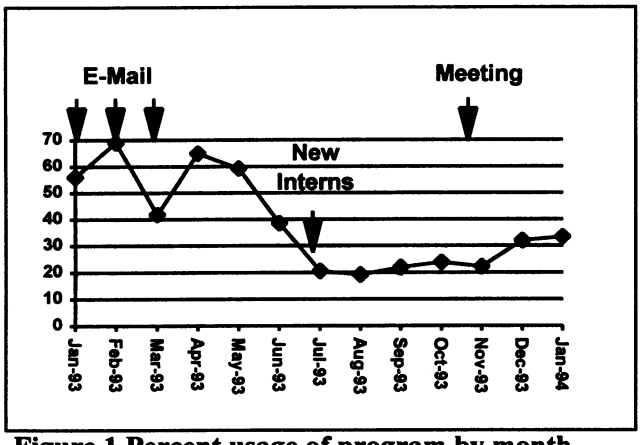

Figure 1 Percent usage of program by month

Patients for whom the program was used tended to be older and had longer hospitalizations. There was no difference in the number of procedures, HIV status, insurance status, number of medications in the hospital, or whether or not the patient was followed in our group practice.

Patient questionnaire results revealed no statistically significant differences between groups, but there was a tendency towards improved self-reported compliance in the patients who received the intervention (96 vs 87 percent, p=0.3).

CONCLUSIONS

We conclude that a computerized system to help interns develop a list of medications at the time a patient is discharged from the hospital, to print patient educational materials, and to communicate these changes to the primary care providers is helpful and felt to be worthwhile by house officers, primary care providers, and nurses. Patients receiving printed educational materials had better adherence to their medical regimens, although part of this might be explained by patient characteristics that we could not measure. The program was preferentially used for older patients with longer hospitalizations, probably because the house officers' perceived benefit of using the program was greater for more complex cases with greater potential for mistakes, drug-drug interactions, and inadequate medication teaching. We found no statistical differences in intervals to emergency readmissions or in rates of adverse drug events causing readmissions.

There are three possible explanations for the lack of statistically significant differences in patient outcomes. One is that the program had no real benefit. This seems unlikely given the face value of the system and the uniform direction of the results.

Another possibility is that the program was effective but that we did not have statistical power to show that it was, because of inadequate sample size and/or high variability of outcomes. This is quite possible given the small samples in the patient survey, the high variability of time to subsequent admissions, and the low frequency of adverse drug events that were thought to contribute to unplanned readmissions. We are currently trying to decrease the population heterogeneity by performing a matched analysis of the data.

The third possibility is that we did not measure the proper outcomes—measuring the impact of such a complicated intervention is difficult. We could have assessed patient knowledge by querying patients about specific features of their discharge medications, and we could have observed primary care visits to determine whether medication regimens were more accurate, or being followed more precisely, saving time during the visits. These measures may be included in future studies.

Sixty-one percent of the eligible house officers used the program for 38 percent of the eligible patients. Although this is quite good in a purely voluntary system, could we have increased it? It was clear that interns needed to be reminded about the system when it was first available, and e-mail and meetings certainly helped in that regard. It is interesting that use among the new interns increased without reminders or education, suggesting that the new interns found the program useful independent of reminders.

Perhaps the new interns should have been pursued as vigorously as the first group, or perhaps we should have petitioned the department of medicine to mandate that all interns use the system when sending patients home from the hospital. One of the difficulties we had was that the program was not universally available on all the floors on which the interns took care of patients. Perhaps a time-series or crossover trial would minimize this problem. Other factors that affect an intern's decsion to use the program include the amount of time saved, the encouragement of the nursing staff, the desire to provide good patient care, and the praise of the attending physicians.

Several issues arose after the system was installed. For example, once the nursing staff began to see the laser-printed patient education materials, they wanted to use the program earlier in their patients' hospitalization, so that they might teach patients several days before discharge. The interns were unwilling to take the time to plan their patients' discharge medications earlier, but we made the educational material available to nurses on demand at any time.

Another problem was that the interns felt we were printing too much. They wanted to be able to suppress the printing of educational materials (for patients in whom they felt such information would not be needed or would be detrimental to their care plan) or of specific prescriptions (in patients who already had certain medications at home), and we have decided to allow this.

The primary care physicians who received the most benefit from this program (and the ones who were surveyed) were those in our hospital-based group practice, where the OMR is used. Since many of our inpatients receive primary care in physicians' offices outside of the hospital, we are implementing a system that sends automatically (by fax) a list of medications to these practices at the time of discharge.

The last issue is that this program was not intended to assist in the care of patients not being discharged to their homes. For these discharges, printed prescriptions are no longer neccessary, but medication decisions remain important, and a large amount of clerical work is involved. We are enhancing the program to offer the creation of an inter-agency referral form, thereby providing incentives for the use of this system even for patients who are not sent home.

In view of user satisfaction and the apparent value of this program for patients sent home from the hospital, we are making it available to the whole medical service and later to the entire hospital. As the OMR becomes available to other specialties and to community-based providers, this discharge medication program will become increasingly useful.

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